Vol. XI MAY, 1924 No. 5

JOURNAL
OF THE
BOSTON SOCIETY
OF
CIVIL ENGINEERS

1848
BOSTON
SOCIETY
OF CIVIL
ENGINEERS

Published monthly, excepting July and August, by the Society,
715 Tremont Temple, Boston, Massachusetts.

Entered as second-class matter, January 15, 1914, at the Post Office at Boston, Mass.,
under Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in Section 1103,
Act of October 3, 1917, authorized on July 16, 1918.

Subscription Price, $4.00 a year (Ten Numbers)
50 Cents a Copy

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Boston
Wright & Potter Printing Company
32 Derne Street

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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POWER REQUIREMENTS AND SOURCES OF SUPPLY OF NEW ENGLAND

By Chas. T. Main, Henry I. Harriman and Dugald C. Jackson

(Presented at a Joint Meeting of the Affiliated Technical Societies of Boston and the Associated Industries of Massachusetts on April 29, 1924.)

Introductory Remarks by Clifford S. Anderson *

The presiding officer has the pleasant privilege tonight of addressing the Affiliated Technical Societies of Boston and the Associated Industries of Massachusetts, assembled in a meeting held under the joint auspices of these two societies to listen to a personal presentation of a report on the power situation in New England by the members of the committee appointed by the Associated Industries of Massachusetts to consider this important subject.

It is a matter of satisfaction that many individuals present are members of both organizations, for it is a notable fact that our industries are now in a large measure manned by technically trained men, and that the majority of our New England engineers have supplemented their theoretical equipment by practical experience at important posts in the various industries of Massachusetts.

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* President, Associated Industries of Massachusetts, 950 Park Square Building, Boston, Mass.

The aboriginal red men who lived in this part of the country where we are now assembled were accustomed, in time of need, to look to some greater power than themselves. Their prayers were made to the Great Manitou, and his answer came in the form of the various activities and phases of nature itself. The sun rose and warmed the red man; in the soil he found the material for his tools, utensils and weapons; and from the animals of the field and forest he secured his food and raiment and shelter. The streams gave up their riches to him and furnished the highways upon which he traveled.

Likewise, the "paleface," in time of difficulty and of need, again looks to the greater powers of nature for the solution of his problems. The stored-up rays of the same sun now burn again in thousands of windows, in cities and hamlets. The lightning has been made a servant. The soil has yielded riches never glimpsed by our predecessors, and now we are looking for a force which shall come to us to run our spindles and turn the wheels of industry.

The engineering profession has been and continues to be pre-eminent in its service to modern mankind in adapting the great forces of nature to modern use. It is not strange, therefore, that when the industries of Massachusetts visualized their need of more electric power, concluded that they must conserve those sources which nature has supplied, must discover by their own ingenuity some method by which to compete with other portions of the country which are able to produce at lower operating cost, and must determine better methods for reducing or at least preventing the advancement of power costs, they should then turn to the engineering profession for advice.

Accordingly, about a year ago we asked a group of individuals who were members of our respective organizations to consider the kinds and amounts of present power, the costs of each and the increase in that cost in the last ten years, the available new sources of power, both within our borders and without, the probable demand for such power, and the cost of supplying it to the industries and public utilities of Massachusetts. We were fortunate in being able to summon to our assistance the chairman of this committee, Mr. Charles T. Main, pre-eminently qualified by study and experience, a man who has turned many a weary waste into a busy hive of industry by his expert planning of efficient power plants. With him was associated Henry I. Harriman, president of the New England Power Company, who could advise how, in the twinkling of an eye, power might be brought from distant sources to our very threshold. B. Preston Clark, vice president of the Plymouth Cordage Company, contributed the wisdom born of many years of experience in applying power to industrial production. Dugald C. Jackson, professor at Massachusetts Institute of Technology, an authority upon all phases of electrical engineering, made his important contribution, and George L. Finch, formerly power superintendent of the Hood Rubber Company, now engaged in consulting engineering, came to the counsels of the committee fresh from active experience in the industrial use of steam and electric power.

I am not qualified to comment upon the report prepared by this committee after a year of careful work. The report itself will reflect the merit of its authors. I desire, however, to call attention to the spirit in which it has been drafted. Its authors have worked without compensation and have been performing a labor of love in the nature of a public service for the public good. I hope those of you who are interested in the report from a technical point of view, and others who may consult it for their own purposes and to obtain from it the important truths which it contains, will also duly appreciate and emulate the spirit which has dominated the group of men who have brought this important study to completion.*

It would be unbecoming for me to attempt to introduce these gentlemen to you. They are your own brothers and associates, and I would virtually be "carrying coals to Newcastle." I shall merely present each speaker and announce his topic.

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* The Summary and General Conclusions of the Report of the Power Investigating Committee will be found on pages 223-227.

Chas. T. Main*

I. GENERAL STATEMENT — REASON FOR AND MANNER OF CARRYING OUT THE WORK

The item of power is usually not the largest factor affecting the cost of the product of our industries, but is of such importance as to cause the Associated Industries of Massachusetts to believe that the subject should be investigated, with a view of ascertaining the sources from which an adequate supply of reasonably cheap power can be obtained.

A committee was appointed by the Associated Industries of Massachusetts on March 21, 1923, to make a study of the power situation in New England, and to report back to the Association at the earliest possible date.

The first thing for the committee to do was to visualize the work to be done and the results to be obtained, and the method of accomplishing them. The work was split up into its component parts, and subdivisions to be investigated were outlined as follows:

1. The kinds and amounts of the present power.
    - *a.* Steam power produced by the public utilities.
    - *b.* Water power produced by the public utilities.
    - *c.* Steam power produced by the industries, whether converted into electric current or transmitted mechanically.
    - *d.* Water power produced by the industries, electric or mechanical.
2. Cost of present power.
    - *a.* Cost of steam power in public-service corporations.
    - *b.* Cost of water power in public-service corporations.
    - *c.* Cost of steam power in industries.
    - *d.* Cost of water power in industries.
3. Available new sources of power.
    - *a.* Massachusetts.
    - *b.* Outside of Massachusetts.

---

* Industrial Engineer, 200 Devonshire Street, Boston; Chairman of the Power Investigating Committee of the Associated Industries of Massachusetts.

4. Probable demand for power from new sources.
    - *a.* Rate of increase.
    - *b.* Transfer from steam to water power.
5. Probable cost of supplying power from new sources.
    - *a.* To the industries.
    - *b.* To the public-service utilities.
6. Prices of coal.
7. Fuel oil for power in New England.
8. Diesel engine.

Each subdivision was assigned to some person or organization to investigate and report back to the committee. Assignments were made for visits to and examination of such properties on which reports were desired and which were not already known to some member of the committee. A questionnaire was sent out to the industries for information on the cost of steam and water power.

As the work proceeded, it seemed desirable to add a division on the possible electrification of railroads, a division on the fuel problem, and to touch upon other possible methods of producing power.

Realizing that no job is ever quickly or properly completed unless there are one or more giving undivided attention to it, the committee engaged the services of Karl R. Kennison, consulting engineer of Boston, to collect and analyze the great mass of data and weld it into suitable form for its consideration, and George C. Danforth, formerly Chief Engineer of the Maine Water Power Commission, for special studies of the water-power resources of New England.

A vast amount of information has been collected and published by public boards of the various states. Such information has been freely furnished by the Departments of Public Utilities of the New England States, and by the Department of Labor and Industries of Massachusetts.

Special requests of the committee have been freely met by a large number of public-service corporations, railroads, engineers in private practice, and associations, which have provided information which cannot be found in public print, and which was necessary in order to get at actual conditions and costs.

The engineering associates of members of the committee have contributed largely in working up data of various kinds and in the preparation of the report.

All of the information was collected, analyzed, and sorted out, and a chapter was written on each of the principal divisions. These chapters were not written in any consecutive order, but after preparations were arranged and harmonized.

After they had been put together, a summary of the whole was written and presented first in the report, the chapters following as appendices. Necessarily, the summary cannot contain complete and satisfactory information, and the whole report should be read in order to get the best part of it.

The above describes briefly the method of procedure. It required about a year's time on the part of all engaged in this work to collect and prepare the information and write the report.

II. Meaning of Report to the Industries and the Service which it can Render

It might be more fitting for a representative of the industries, for which the report has been prepared, to interpret what the report means and the service it can render. I have possibly been too close to its preparation to see it in perspective, but I can say what the committee hopes it has accomplished.

The committee has collected, through the name of the Associated Industries of Massachusetts, data and information which would have been impossible for an individual or a firm to have secured, and collectively has been able better to interpret this information, assisted by their joint knowledge, than any one individual or firm could have done. It has endeavored to present a picture of the present status of power production in New England, its probable growth in the near future, and the manner in which the future requirements can be furnished most economically.

With these data available, manufacturers and other business men in New England will be in a position to determine what is the best policy to adopt in regard to the future supply of power.

The report can roughly be divided into two principal parts: (1) Power Requirements and (2) Availability and Cost of Power.

Power Requirements

This can be divided into three parts: (*a*) How Fast is New England Growing? (*b*) How Much Power will be Required in the Next Ten Years? (*c*) Where is the Power Required?

(*a*) *How Fast is New England Growing?* — A study was made of the industrial growth of New England by analyzing data on the power requirements of industries, the number of wage earners employed, the number of spindles in the textile industry, and the ton-freight mileage of railroads.

(*b*) *How Much Power will be Required in the Next Ten Years?* — Apparently power requirements have been steadily increasing at a rate which points to a growth of from 15 to 20 per cent in the next ten years, as a conservative estimate. This applies equally well to New England as a whole, or to Massachusetts, which is approximately half of industrial New England.

The power generated annually in recent years by central stations has been determined closely by analyzing and correcting published records. The amount generated by the industries has been estimated. The growth of central station power has been and will be much larger than the increase of power produced by the industries. The indications are that the total requirements will increase 15 to 20 per cent in the next ten years, but that the central station growth will be not less than 70 per cent.

The indications are that the growth of the total power for the Massachusetts–New Hampshire–Rhode Island group, conservatively estimated, and not allowing for extensive electrification of railroads, will be at the rate of 80,000,000 to 100,000,000 Kw. H. per year, while the growth of that part generated by central stations will be about 190,000,000 Kw. H. per year. To accomplish this there will be required about 900,000 Kw. net increase of generating capacity in the utilities, in addition to replacements.

Massachusetts, Rhode Island and New Hampshire are already so interconnected with transmission lines that for the purpose of studying power conditions it is necessary to treat these states as a group rather than by political divisions. The load center for this group is in eastern Massachusetts.

If that part of the railroads of New England on which traffic conditions warrant electrification can be electrified, about another 950,000 Kw. station capacity would be required. The outlook for electrification, however, in the immediate future is not bright.

(*c*) *Where is the Power Required?* — The report shows the geographical distribution of central stations and of the industrial power load, and where the additional power will be required.

It shows that the increase in power capacity of the public utilities is going on at a greater rate than the increase of capacity in the industries. This is due to the increased use of electrical current for lighting and other purposes, and because many of the industries are being run in part or in whole from central stations.

There must be an economic reason for this, and it is an indication that it may be better for some new industries to save investment in power plants, and for some old industries to purchase power, and that each case should receive careful consideration.

Availability and Cost of Power

Availability. — There is a prevailing idea that there is a large amount of water power in New England going to waste which could be utilized at low cost. I presume that one of the chief reasons for this investigation and report was to prove or disprove this idea.

It is true that if all the undeveloped water power in New England could be economically developed, and the electric current transmitted to the markets as fast as it could be absorbed, it would take care of the growth in requirements for about fifteen years, not considering the electrification of railroads, but only about 60 per cent of this could be developed at a cost which would assure a fair return on the investment, and of this all but a small portion is in Maine, and under the present laws cannot be exported.

While this may be a disappointment, it is well to have the impression that there is a large amount of water power available in Massachusetts dispelled. Some of this water power will in time be developed for local use, but it has no important bearing on the problem of obtaining a sufficient supply in the near future.

The total water power from various sources (now economically available to southern New England) is relatively small compared with the total requirements for the industrial growth, although important to individual plants.

The great bulk of the power for New England's additional requirements must come from two sources:

Large public-service steam plants in favorable locations.

Large water powers of Canada, including those on the St. Lawrence River, if proper arrangements can be made for the export of electric current.

All interconnected so as to run on high load factors at minimum operating costs.

Cost of Power. — The value of the undeveloped water powers in New England depends largely on the possibility of adequate pondage and their use with high load factors. Many possibilities which could not stand as isolated plants may be of value as feeders to central station loads. About 60 per cent of the undeveloped sites can eventually be developed to deliver nearly three billion Kw.H. at a price from 0.7 to 2 cents per Kw.H. in large blocks. The estimated cost of such developments, based on present costs, varies from $50 to $500 a H.P.

The approximate amount that can be developed and delivered within certain limits of cost, if under favorable conditions of load, is as follows:

Kw.H. Available for Sale.	Cost of Delivered Power for Large Users, in Cents per Kw.H.	Per Cent of Total Kw.H. Available at Stated Unit Costs.
917,500,000	0.7 to 1.0	19
1,207,500,000	1.0 to 1.25	25
773,000,000	1.25 to 1.50	16
434,500,000	1.50 to 2.00	9
338,000,000	2.00 to 2.50	7
676,000,000	2.50 to 3.00	14
483,500,000	over 3.00	10
4,830,000,000	— —	100

These water powers are scattered over New England. Only a small amount is in Massachusetts; about 75 per cent is in Maine, a considerable distance from the Massachusetts market, and at present unavailable.

Sufficient studies have been made to show that some of the nearer Canadian powers can be developed and the current transmitted to the power center of Massachusetts, and delivered to customers using large quantities, at probably not over $1\frac{1}{4}$ cents per Kw.H.

Estimates have been made of the cost of generating power from large steam stations built on tidewater. The cost to large takers located near the stations should be not over $1\frac{1}{2}$ cents per Kw.H. Predictions are that these larger tidewater steam stations should make a total saving to the user of about 2.8 mills per Kw.H. over present practice in the better stations in New England.

The operation of large tidewater steam stations in conjunction with imported water power is not expected to make any large direct saving over a large all-steam station operating with the best economies now in use, but the introduction of water power into such a steam system will have beneficial results, such as —

(*a*) A reduction in the probability of interruptions due to coal and railroad strikes.

(*b*) The effect of the reduced demand for coal on its price.

(*c*) The relief of New England railroads from some of the coal freight.

(*d*) The conservation of the fuel resources.

The cost of central station power in 1922 averaged 3.54 cents per Kw.H., delivered to the customer, including the more expensive domestic delivery. The present published rates to large consumers located near central stations, having a load similar to that of textile mill, are as follows:

Demand in Kw.	Rates per Kw.H., in Cents.
500	1.69 to 2.46
1,000	1.69 to 2.45
2,000	1.40 to 1.90
3,000	1.35 to 1.90
5,000	1.29 to 1.73
10,000	1.20 to 1.69

III. Cost of Power Production in Isolated Plants

Cost of Steam Power Developed by the Industries

The cost of steam power for the industries produced by isolated plants will vary with the size of the plant, the load factor, and the cost of fuel.

With the cost of plants as in 1923, operating 2,400 hours a year, on loads similar to those of a plain textile mill, and with coal at $8 a short ton, the cost per Kw.H., including all charges, would be about as follows:

Size of Plant in Kw.	Cost per Kw.H., in Cents.
1,000	2.84
2,000	2.41
3,000	2.26
5,000	2.01
10,000	1.67

For each dollar change in the price of coal per ton there will be a corresponding change from 0.15 to 0.10 cents per Kw.H.

In some industries there is use for low-pressure steam and warm water in the manufacturing processes, and these can be furnished after they have been used in making power. In such cases the net costs of power are less than those given above. If all of the warm water and exhaust steam could be used, and credits given for fuel, fixed charges, and attendance chargeable to manufacturing, the net costs would be about as follows:

Size of Plant in Kw.	Cost per Kw.H., in Cents.
1,000	1.25
2,000	1.00
3,000	0.90
5,000	0.80
10,000	0.70

or less than half the cost, with no use for the waste heat. Most cases having use for waste heat would come in between the extremes mentioned.

The cost in paper mills running twenty-four hours a day are much less than in cotton mills running eight hours. Without any credit for the use of exhaust steam, the costs would be about as follows:

Size of Plant in Kw.	Cost per Kw.H., in Cents.
1,000	1.84
2,000	1.64
3,000	1.48
5,000	1.34
10,000	1.13

These figures of cost indicate that some industries can better afford to purchase power than to make it. The chief factors in the determination of this question being:

The size of the plant.

The possibility of using the waste heat of the power plant in the manufacturing process.

The hours of operation.

The Fuel Supply

One of the things the committee has tried to impress on the reader of the report is the fact that no matter how much water power development is made, it is impossible to prevent the increasing consumption of fuel and the necessity of limiting this as much as possible, not only for the purpose of keeping present costs down, but for conserving the supply.

We have an enormous coal reserve in this country, but it is becoming difficult and expensive to mine and deliver it.

The United States is producing oil at a rate which would exhaust estimated oil reserves of this country in about thirteen years.

Dean Holbrook of the Pennsylvania State College, School of Mines, has recently said:

> Coal is, and must continue to be, the foundation of our industrial civilization, and the basis of our organized life. It is a non-replaceable asset whose supply has been bounded by a term of years comparable to our Christian era. For all we know, to-day, there is no substitute to furnish the vast quantities of power increasingly demanded. Common decency for the coming generations demands a rational program of conservation, production, and utilization.

In closing, I desire to say that this report is not intended to furnish a method of solution of any individual power problem, but is intended to cover broadly the subject of power supply for Massachusetts and New England as a whole, and to set up general limits of application to the industries.

The report shows, what has already been outlined in the beginning —

1. How much power is now being used.
2. How much power will be needed in the next ten years.
3. The sources of present power.
4. The sources from which the increasing needs can be supplied.

5. Probable limits of cost of the additional power required.

6. That fuel can be conserved principally by making use of water power in Canada, including the St. Lawrence River, if the necessary legislative and financial arrangements can be made, and, to a smaller extent, covering a longer period of time, by the development of those powers which are economically sound and by the redevelopment of existing properties to obtain greater efficiency in the use of water.

With this data available, the principal power producers and users should be assisted in solving their power problems.

Henry I. Harriman*

Mr. Main has discussed the general outline of the report. Mr. Jackson, who is to follow me, will discuss the question of hydro-electric power, especially power brought in from Canada. The subject assigned to me is the general one of the interconnection of existing power and sources for possible additional supplies of hydro-electric power for New England. Before taking up this subject, I want to express very briefly, for myself and I am sure for the other members of our committee, our appreciation of the very earnest, thoughtful, and continuous labor which our chairman has put into the preparation of this report. The committee has worked harmoniously and in unity in the preparation of this report, but it is to the chairman we are chiefly indebted for what I believe is one of the most unique and one of the most carefully prepared reports which has been presented for the consideration of New England industries. The subject which has been specifically assigned to me divides itself into two parts, — the question of interconnections and the question of sources of additional supplies of hydro-electric power.

Interconnection between Utilities in New England

The underlying thought of interconnection between the various electric companies of New England and New York is that each of these companies operating separately must have a large source of surplus supply; that is, every steam plant must have a capacity sufficient to deliver its load with its largest unit out of service. As the electric plants are putting in larger and larger units, — 30,000, 40,000, and 50,000 Kw., — it is evident that a group of ten, fifteen, or twenty independent companies therefore have a large supply of surplus power not required at all times and available in emergencies, some of which, if the companies were interconnected, could be furnished to any one company when it was in need of assistance. These interconnections first bring to thought a saving in capital investment in plant, but the benefit goes farther than that. It is recognized that some plants are very efficient, that others are not so efficient, and also that some are very inefficient. The electric industry does not have a uniform load throughout the day, nor does it have uniform loading throughout the year. The statement is frequently made that 50 per cent of the capacity of the steam plants of the public utilities is not operating more than 5 to 10 per cent of the time. It is perfectly evident, if there are groups of steam plants with varying efficiencies, that it will pay to carry the base load and the bulk load on the most efficient plants, and use the inefficient ones to carry the peak loads that occur only a few hours in the year. A steam plant running several thousand hours in the year can afford to put in expensive equipment, but one running only three or four thousand hours a year can ill afford such refinements as oil-saving equipment, and so forth. So the second thought is that the most efficient plants should carry the bulk load and the less economical plants the peak load. When this is done the real capacity of the interconnected system will be much increased, because there are many relatively obsolete plants that a company would not wish to rely on for continuous service that can well be kept for occasional peak hours of the winter, or occasional breakdown emergency service.

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* President, New England Power Company; Member, Power Investigating Committee of the Associated Industries of Massachusetts.

So there is very real economy to be achieved by the interconnection of the large and the medium-sized steam plants, and if you interconnect also the water powers you add still another source of economy. Particularly in New England there is a great difference in flow between maximum and minimum. There are times when our water powers are very short of water, while in other seasons there are great surpluses. The water-power supply in a single company is limited in its output to what that company can put to use; but if through interconnection the surplus night power can be poured into other plants, it is evident that there will be effected during the year a very large economy in putting waste power to work and in conserving our fast dwindling sources of supply of oil and coal.

First let us consider the location of the large steam plants. Obviously, the largest and most efficient electric power plants are on tidewater, where coal can be brought in by boat, and we have today large steam plants in Boston, Salem, New Bedford, Fall River, New London, New Haven, Devon, and Bridgeport. There is also a large plant at Albany, and in New York there are four or five huge steam plants. While these are the largest and best in plant, there are others that are efficient and that may well be used at Worcester, Uxbridge, Lowell, Chicopee, Springfield, and Hartford.

It is evident that if these various plants, together with the larger water powers (the largest are those of the Turners Falls and the New England Power Companies), were interconnected there would be great economy of operation.

A study is now being made, under the auspices of six of the largest utilities, of what real economy can be effected by such interconnections. Mr. Jackson is actively co-operating in this work, and I believe when the report comes out it will show some astonishing figures as to the economy to be effected by interconnection. I will only say that the very brief studies already made by the committee point out that if these large steam plants were connected their combined capacity would exceed by 600,000 Kw. the combined simultaneous load of those companies. It will probably not be feasible to utilize this entire surplus power. It will be very difficult, indeed, to connect some of the large steam plants of New York so as to bring out a large supply of power from them, but I do not think it is an exaggeration to say that the committee investigating this subject will be very much disappointed if they do not find 300,000 Kw. of spare capacity. That means an investment saving of from $30,000,000 to $40,000,000. I have been asked to outline how far interconnection has gone. A good deal has been done by various companies in connecting certain of their plants. For instance, the plant of the Boston Edison Company is connected by a 60,000-volt line to the plants of the New England Power Company, and those in turn to the Turners Falls Company, whose lines in turn connect with the Hartford plant, whose lines connect with the new plant at Devon. The lines of the New England Power Company's plant interconnect with steam plants at Worcester, Uxbridge, Springfield, North Adams, and other places, thus effecting a general connected system. But these connections thus far built have been pioneer and test connections. They are 60,000-volt connections and do not have over any of their circuits a capacity of over 15,000 or 20,000 Kw. They are not large connections in view of the large possible connections that may be required if the spare capacity of these power plants is to be really effectually united.

Then it is probable that the existing 60,000-volt lines will become feeder lines in an interconnection system of a few great trunk lines of 220,000 volts that will be built to bisect New England and connect plants at Boston, New York, and elsewhere with the water powers of southern New York and New Hampshire. No estimate has yet been made to show the cost of this work, but it is my belief that the cost will be far less than the value of the interconnection. Again, however, I must ask you to await the report of this committee of the utilities, which is making this careful study of the details of the question.

Sources of Supply of Additional Hydro-Electric Power

The second part of my subject deals with the possible sources of supply for additional hydro-electric power. Mr. Main has discussed the question of load with you. He has shown you that there is in New England a possible load today of not far from five billion Kw.H. which will increase rapidly to a far greater figure. You will remember that the report of the Superpower Survey, made by Mr. Murray, indicated that for a power zone which ran from Boston to Washington there would be in 1931 a total electrical and mechanical load of about thirty-one billion Kw.H. Recent studies have developed the fact that when we are really considering the workshop of North America, we must extend the limits of the zone westward to Cleveland, taking in Pittsburgh and the great manufacturing territory of Pennsylvania and Ohio. If we take this large Superpower Zone into consideration, we find forty-five to fifty billion Kw.H. to be the load of the district.

What are the possible sources of hydro-electric power for supplying this workshop, where are they located, and what are their capacities? The first great source of supply is Niagara Falls, where the water of Lake Erie drops 307 feet between Lake Erie and Lake Ontario. That power has only been scratched. The initial developments were made only under partial head; that is, a head of 120 to 150 feet. It is only recently that on the Canadian side one development has been made which takes in 305 feet of the total fall; and it is estimated if Niagara Falls were fully developed and remedial works allowed at the top so that sufficient water would still go over the falls in order that the scenic effect would not be spoiled, there would be possible a development of thirty billion Kw.H.

The second great source of supply is the St. Lawrence River, on which stream between Ogdensburg and Montreal there is a total drop of 220 feet. This fall is divided into three sections, to wit: the International Section, with a fall of about 90 feet; the Cedar Section, with a fall of about 88 feet; and the Montreal Section, with a fall of about 42 feet. The three sections when completely developed are capable of producing thirty billion Kw.H. of continuous and reliable power.

There are also several large Canadian rivers which rise in the table-land to the north of the St. Lawrence, and between their source and their mouth have a total fall of from twelve to thirteen hundred feet. The table-land on which these rivers rise is flat and swampy, with large lake areas capable of development into huge storage reservoirs.

Among these rivers the Ottawa is one of the largest, and among the large power possibilities of this river may be mentioned the fall at Carillon, where there is a drop of 60 feet, — a potential power of two billion Kw.H., — and the undeveloped energy of the river is certainly not less than eight billion Kw.H. Mention should also be made of the Gatineau, a branch of the Ottawa, with a total fall of 1,000 feet, and a potential power of three billion Kw.H.

On the Saguenay River, at the mouth of Lake St. John, there is a fall of 300 feet. Back of this fall there is a drainage area of 20,000 square miles, and sufficient storage in Lake St. John and other lakes to equalize the flow of the stream throughout the year. This power alone can produce more energy than could be used in the New England States.

There are also large powers on the St. Maurice River, and it is fair to assume that the rivers north of the St. Lawrence can generate not less than thirty billion Kw.H.

Canada is not our only source of power supply. Two billion Kw.H. can be developed in the state of Maine, but the present laws of that state prohibit its exportation. Probably another billion Kw.H. can be developed in New Hampshire and Vermont, but developments there are relatively small in size and not as economical of development as the larger powers of Maine and Canada. There is also the possibility of developing several billion Kw.H. in the Adirondack and Hudson River regions.

To summarize, thirty billion Kw.H. can be developed at Niagara Falls; another thirty billion on the St. Lawrence; still another thirty billion in the Canadian rivers to the north of the St. Lawrence Valley; and an additional ten billion in Maine, New Hampshire, Vermont, and New York. In other words, we have a power house in which can be developed one hundred billion Kw.H. of hydro-electric energy and a possible market for fifty billion Kw.H.

I would not have you think for one minute that the steam plant is going to be obsolete. The steam plant has its function, for these great cities are not going to be entirely dependent upon power supplied from long distances. Electric transmission will always, in my opinion, require large steam plants as relays, but I believe as time goes on these great powers that lie to the north of the market will gradually be developed and become greater and greater factors in supplying our utilities and industries with the power which they need.

Dugald C. Jackson*

This report, when read by an industrialist who wishes to learn what significance it may have to the industries of Massachusetts, should first be impressed by the tables and charts of growth. This also should be impressive to the members of the Affiliated Technical Societies of Boston. Surveying the future from the standpoint of the past development and existing conditions, it appears that the industries of Massachusetts may be expected to increase in output and in employees by an amount equal annually to probably $1\frac{1}{2}$ per cent of the present amounts, and possibly at the annual rate of 2 per cent. This applies to the New England industries as a whole, and is equally applicable to Massachusetts. It does not apply to single industries in either the comprehensive New England territory or in Massachusetts, but applies to the aggregate of those industries.

The population of New England increases at a somewhat smaller rate, namely, 1.3 per cent of the present population is what may be expected to be added annually. The horse power per wage earner in New England (using the United States census figures) during the two decades of 1899–1919 has steadily increased, thereby indicating the greater use of machinery, and perhaps the use of automatic devices for the purpose of reducing the cost of manufactured products. The number of wage earners in New England and also in Massachusetts has at the same time increased.

When referring to the matter in this way, I do not use the individual data of a year, but am using the general trends. There are some features at the present moment that give certain color of pessimism in some of the industrial branches of New England, but any one who is a "bear" upon the further life of the New England industries or the Massachusetts industries taken in the aggregate surely is basing his pessimism on something other than the facts that stand out in this report. With this development it is necessary to have developed power.

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The question that we ask is how it may be secured. If all the undeveloped water power in New England, available in units of 1,000 H.P. and over, should be brought into service for the industries, it all would be absorbed by the growth of ten to fifteen years. It therefore is not sufficient and must be reinforced, either by steam or by power from the great water-power sources of the north, or by both. This statement is made quite independently of the fact that a good deal of the still available New England power is in Maine, and under present legal restrictions cannot be usefully applied in the greater part of the New England territory.

We also can consider what a central station manager may learn of significance from this report, and find that he will observe that the central station companies are to a greater and greater degree selling power to the industries, often in quite large blocks, and that it is on this market that he relies to a large degree for sales of bulk power which improve the load factor of his generating stations and enable him to maintain a moderate price for the electricity sold to the small lighting customer of small load factor, as well as a moderate price to the industries. He also learns that the conditions of growing normal small use of electricity plus the industrial use will make a demand that will call for substantially doubling the central station power generating capacity in the next decade or a little more. If this is associated with an increased load factor due to the diversity of the hours of use between ordinary lighting and commercial loads and the industrial loads, the Kw.H. of output will be increased in a somewhat larger proportion.

We consequently come to the inquiry of from whence shall the power come. As already noted, the water powers of New England would be quickly lapped up by this demand, and we must either rely upon steam-generating plant or upon water power of our northern neighbor, the Dominion of Canada, with whom we already have so much community of interest. Under such circumstances it is important to compare the relative merits of the two sources.

There is a general conception that water power is much cheaper than steam power. This is incontestably true when only operating expenses are considered, since the water power is operated without expenditure for fuel, which comprises the larger proportion of the operating expenses of a steam power plant. However, the conditions are different in many cases when one includes both the annual operating expenses and the annual fixed charges for investment, which commonly are very large for the water power plant and offset to some degree the lesser operating expense. In fact, this offset at times is so large as to make the water power more expensive than the steam power. Moreover, few people outside of the circles of central station men, who are dealing with the problems of very large steam power plants, have a full appreciation of the tremendous advances in fuel economy which have been introduced during the last fifteen years as a consequence of the construction of larger sized, better designed steam power units, and the use of higher steam pressures associated with the advantages of superheated steam. All these improvements tend toward economy in the use of fuel, and thereby reduce the operating expenses of the steam-generating plant. At the same time they involve additional investment expenditures for plant, but not in sufficient degree to offset the advantages of the economies; and the steam power plant, therefore, has been slowly but steadily improving from the standpoint of the cost of power.

There are other improvements in the wind, such as the use of very high steam pressure, like 1,200 or 1,500 pounds per square inch, and the use of mercury vapor as the first stage in the thermo-dynamic cycle, which may reduce the cost of steam-generated power somewhat further, so that it can successfully compete with water power transmitted from a long distance when the water power plant has to be built under present conditions of cost.

Our steam power will always be dependent upon the supply of fuel, and this fuel for the New England country must be either coal or oil. We have no natural gas. Peat, which is sometimes optimistically referred to, is but a bagatelle, and in addition is not in commercial form for industrial use. We must rely upon coal and oil for fuel-developed power. Experience has proved that oil is a fuel of variable price, and the glance forward into the oil situation, which is contained in the report, shows that it probably will continue to be of uncertain and variable price. It also is indicated that the tendency of the price is likely to be upward.

This leaves us with coal as our great reliance for fuel. Here is a material of which this nation has a tremendous supply; but the delivery of the same to individual customers is entangled with the problems of human labor at the mines, human labor on the railroads, car supply, weather conditions for transportation, and many other features which make the coal supply to an industry a matter of uncertain continuity, uncertain price, and worry to the management. *Therefore, if important water power supplies can be secured at prices even which do not differ materially from the price at which steam power can be secured, such water power supplies ought to be cultivated on account of their stabilizing effect.* They may be serviceable in case of an interruption of fuel supply on account of miners' strikes or railroad employees' strikes, or congestion of the railroads due to weather conditions and the like; but, still more important, they will have a restraining influence against the tendency for such strikes, because it is generally recognized that a strike is less likely to be prosecuted when a substitution can be made for the commodity of which the production would be interrupted by strike.

Of course, the investment of large amounts of money in water power projects merely as a safeguard would not be made. *These water power projects must be used if they are installed.* They must be able to deliver power with reliability, at a price which makes it practicable to compete with continuous steam power, even though it is necessary to fortify the water power projects with steam power in order to take care of the exigencies of dry seasons, interruptions of power transmission lines, and the like disagreeable phenomena.

The comparison of the cost of the Canadian power on which we must rely for our larger additions to existing hydro-electric power and steam power generated in great central stations at tidewater is a factor of importance to the manufacturing industries. A factor of greater importance to them is the cost of transmitted water power from large sources compared with the cost of steam power generated in their individual power plants. The report deals with both of these subjects.

At the top of page 137 of the report there is exhibited a significant table showing the cost of power in textile mills working on cotton goods and not needing steam for process.

For those who complain of the price at which power is now offered them by power-distribution companies, a comparison of the table referred to with the one at the foot of page 136, showing the cost in similar mills fourteen years ago, should be enlightening.

The table at the top of page 137 relates to coal at $8 per short ton, but any mill which is buying coal at a lower price may make the correction and still the cost of the power in new plants must be shockingly high compared with what it was in 1910 for corresponding plants. Of course, where the plants are old the investment costs of earlier days determine the fixed charges instead of the investment cost of the present day, and the power cost will lie between the two tables. These tables show, however, that power-distribution companies which secure their power from hydro-electric stations, and those which secure their power from steam-power generating stations, both sell power at prices that should be recognized as attractive to these textile mills, and the mills should profit by relieving themselves of the necessity of spending further capital for nonproductive power plant and the necessity of supervising the generation of their own power.

Comparison of Cost of Canadian Power and Steam Power Generated in New England

A very significant point in the report is the comparison between the cost of steam-generated power and Canadian power. The report points out in the section on the cost of Canadian power delivered in New England, which begins on page 128, that Canadian power may be delivered to large customers for perhaps as little as 1.25 cents per Kw.H., provided the load factor of the customer is high enough, as, for instance, 50 per cent per annum. This is a higher load factor than is secured from individual industrial plants in New England. Likewise, in the section relating to the cost of generating power in new large steam-generating stations at tidewater, which begins on page 146 of the report, it is stated that it seems probable that the price of energy from large and efficient modern steam stations delivered to near-by industries, taking large amounts, would be about 1.5 cents per Kw.H., to which should be added the cost of transmission in the case of industries located at a distance.

Here the price is named on the industrial load factor. In consideration of the Canadian water power transmitted by long lines above referred to, the load factor was higher than the ordinary industrial load; and when corrections are made for this difference the two prices, namely, that at which Canadian water power may be sold to the industries and that at which steam-generated power may be sold to the industries, run substantially on all fours. This brings us to a very important fact, one vital for consideration and reflection.

Since water power is greatly affected by the seasonal conditions of river flow, and long-distance transmission lines are subject to interruption caused by the elements, it is desirable, and in fact important, if reliable service is to be given, for the water-power projects to be fortified by steam-power generating plants. Under these circumstances it is obvious that the economic considerations lead flatly to the association of the hydroelectric projects and their long lines with the steam central station projects owning large economical tidewater generating stations and comprehensive distribution systems. The price available from either is about equal to that of the other for industrial use. The association of the two secures reliability of service as well as seasonal continuity. The price practicable to fix by either for industrial customers gives a material saving compared with the cost of power in individual new plants at the industries. The industries cannot expect to save greatly on their power, but where the total use involves such majestic numbers, a small saving per unit makes a large aggregate saving for the benefit of the aggregate prosperity of New England. Every mill (0.1 cent) saved for each billion kilowatt hours annually consumed by industrial New England means a saving of $1,000,000 to be added to the general prosperity, and every mill saved on the five billion kilowatt hours of electricity which soon will be used in industrial New England (exclusive of future use by the railroads) means $5,000,000. While this is not an important percentage on the value of the total New England production of manufactured goods, neither is the total cost of power a large proportion of cost in the New England production.

The principal feature which should be considered is an ample supply of power at a reasonable price and reliably delivered. The New England use of power per wage earner has steadily increased during the last two decades. This is an indication of the increase of production per employee. It is also an indication of a larger use of automatic machinery. Following the consensus of opinion of the manufacturing nations of the world, the welfare of our territory depends upon the encouragement of this tendency, and a large and ready reliable source of power is important for carrying this out.

Reliability may be more important in some instances than the price of power *per se*. For instance, ordinary industries operating their own power plants and having interruptions to service on account of difficulties with the power apparatus which are causing from twenty to thirty hours' loss of time per year in brief periods varying from a few minutes upwards, could better afford to pay from 10 to 40 per cent more for the power and do away with these interruptions than to economize on their power costs. The proportion that they could better afford to pay to secure greater reliability of power supply depends upon the character of the industry and the relation of raw material expense to labor expense, overhead expense, and proportion of profits. The larger the proportional labor expense the more costly these interruptions become, and the more the industry can afford to pay for power of the highest degree of reliability. This is a point that industrialists sometimes forget, but it is worth while to remember that power distributers make reliability of service one of their principles.

Returning to the idea suggested earlier, respecting the growth of New England, and emphasizing the fact that New England is not decadent, it is important to bear in mind that the production per population of manufactured products in New England has for several decades and still does stand at nearly twice as high a value as the average for the United States.

Some industries may feel pessimistic, but others are going forward to take their place. The greater encouragement of power projects which will bring a large bulk of reliable power to the doors of the industries, tying the great water powers of Canada to the great steam stations of New England with their distribution systems, and intertying these with the water powers of New England, is an element fraught with so much importance to the industries of New England, both present and prospective, that all industrialists may profitably give their attention to the matter and encourage the development.

New England is peculiarly fortunate in already possessing a number of large and notably economical steam-power generating stations at tidewater associated with comprehensive distribution systems, and a general development of transmission circuits belonging to hydro-electric companies owning important water-power plants. These make a desirable foundation for the greater power system that may serve to provide the large additional power which the industries may find advantageous to use. The further development of these systems and the introduction therein of great quantities of power from the north cannot fail to bring in their train a greater facility in the use of power and economy in price, besides aiding in the conservation of fuel, in which all the nation is interested.

Discussion

Mr. Anderson: I would like to briefly enlarge upon one point referred to by Mr. Main in the course of his remarks and call your attention to the fact that the committee had at its service paid technical advisers who made no small contribution to the preparation of this important report. Their part in the undertaking was made possible by the generosity of about fifty members of the Associated Industries of Massachusetts, who contributed the sum of sixteen thousand dollars, which has been expended to obtain the necessary technical assistance. If we find the report of great value, we must recall that a large share of our thanks is due to those companies and individuals who, by their generous contributions, have made this report possible.

I should like to call your attention to one feature of the arrangement of the report which is somewhat unusual. The committee, with wisdom born of experience, has prepared a summary which constitutes the body of the report. This has been made brief in the hope that the maximum number of readers will thus be induced to cover in some measure the entire ground of the report. In view of the brevity of this summary, the Appendix of the report contains vastly more than the usual tables of figures which customarily constitute the major portion of appendices. Under this arrangement, a large portion of the most essential material contained in the report will be found among various titles in the Appendix.

This report, which has been so briefly but so clearly outlined by the speakers, has been released within a few days to the newspapers. Copies of a large but limited edition may be procured at a moderate price upon application at the office of the Associated Industries of Massachusetts.

The study of the St. Lawrence development is alluded to in this report and discussed briefly along with other possible Canadian sources of power; but a particular study of the St. Lawrence project has been delegated to another committee which has not yet made its final report, although the Associated Industries of Massachusetts has already set forth the grounds upon which it believes that the carrying out of the proposed St. Lawrence project is for the advantage of Massachusetts and New England. The present committee has given its attention to more immediate opportunities for securing additional power during the period of eight or ten years which must, in any event, elapse before any power can possibly be secured from the St. Lawrence River. You will note upon reading the report that the committee has been unable to separate the power problem of Massachusetts from the power problems of New England in general. I think that thoughtful men realize also that when we discuss New England questions we cannot and must not try to solve New England's problems without considering the country at large. I earnestly believe that in discussing many broad questions that interest our industries, such as transportation, power, food and fuel, we must approach them from the broad national point of view. Our prosperity in Massachusetts is due to the fact that we are a part of a vast country with resources still subject to development, but, above all, a country which, under the philosophy of our fathers, affords free opportunity for each individual to work out his industrial and social salvation. And the important contribution of the report which we are discussing this evening will be primarily this, — that through the enlightenment received from this report, industrial performance will be enlarged and increased, greater production will follow, and in the future, as industrial progress and inventive genius lead the way, more and more individuals will be released from drudgery, and, through the mastery of men over machinery, our citizens will be better able to reap the greater rewards of earnest effort. Our committee, therefore, has made a tremendous contribution to the cause of advancement of the American citizen and of America at large.

QUESTION: Since the time of greatest danger of interruption to the service of steam plants in New England is in the winter time, of extreme cold, I would like to ask Mr. Main in what measure the same conditions, by way of ice, will interrupt the service from the great Canadian power plants in the time of greatest need?

MR. MAIN: The question of ice trouble on the St. Lawrence River has been discussed at great length in the report of the International Joint Commission appointed to study and report on the development of the St. Lawrence River. There is great variation of opinion on the effect of ice. I can't answer the question definitely and state the exact relationship of the interruption to service between power on the St. Lawrence and from steam power. But judging from many years' experience with the operation of steam plants, I would say that the interruption of the isolated plant is slight. It used to be told years ago that if a steam power plant in Fall River were shut down twice a year the engineer lost his job. So far as I know the interruptions to operation of steam-power plants have been up to the present time rather immaterial. I think Mr. Hugh L. Cooper might throw some light on interruptions to hydraulic stations, due to ice. He says he can design plants there that will not be interrupted at all, while other engineers have placed great stress on interruptions of that nature in the case of plants on the St. Lawrence. I think we are learning a lot about how to take care of ice, and that the power from hydro-electric power stations can be made reliable.

QUESTION: I would like to ask about the possibility of developing electric power in the Appalachians.

MR. MAIN: We have not studied that possibility. Our problem was the development of the power resources of New England. We only went outside to consider what might be brought in from Canada. I would assume that any power developed in New York State would be absorbed in that state.

QUESTION: I would like to ask Mr. Harriman if in the one hundred billion Kw.H. of electric power he mentioned as available in Canada he referred only to that portion not now being used there?

MR. HARRIMAN: In that one hundred billion there are included the eight or ten very large outstanding undeveloped powers.

SUMMARY AND GENERAL CONCLUSIONS OF THE REPORT TO THE ASSOCIATED INDUSTRIES OF MASSACHUSETTS OF ITS POWER INVESTIGATING COMMITTEE *

THE industries of Massachusetts required in 1922 for their load of about 1,250,000 H.P. a total installed capacity of about 1,800,000 H.P. Of this, about 300,000 H.P. was steam-generating capacity in industries which required considerable steam for process work as well as for power.

The total energy used in New England in 1922 (except in steam locomotives) was about 7,500,000,000 Kw.H., of which about one-half was generated by the industries themselves, and the other half by the public utilities. Of this total, about 2,200,000,000 Kw.H. was generated by water power.

The power systems of Massachusetts, New Hampshire, and Rhode Island are already interconnected in such a manner as to make it advisable to treat the power required for this area as a group centering around eastern Massachusetts, rather than to consider Massachusetts alone.

The energy used in 1922 in Massachusetts, New Hampshire, and Rhode Island centering about eastern Massachusetts was about 4,900,000,000 Kw.H., of which the public utilities produced about one-half. Of the total, about 1,000,000,000 Kw.H. was produced by water power and the remainder from fuel.

Judging from the past, the indications are that the total power requirements for New England ten years hence will be at least 15 per cent and possibly 20 per cent more than they are now. The same relative increase will hold for Massachusetts alone.

The rate of increase of the loads on the central stations is greater than the rate of increase of the total power demands, thus showing that the public utilities are taking over a portion of the load of the industries, the power for which was formerly generated by industries themselves. As existing steam plants wear out, they will continue to be replaced by power purchased

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* Copies of the complete report with appendices may be obtained from the Associated Industries of Massachusetts, 950 Park Square Building, Boston, Mass. (Price, $1.50 per copy.)

from public utilities, especially in those industries which do not have important uses for exhaust steam.

It is expected that on an average for the next ten years the load on the public utilities will increase each year by the following amounts, which may be regarded as a conservative estimate:

For the Massachusetts–New Hampshire–Rhode Island group centering around eastern Massachusetts 90,000 Kw. net additional capacity will be required and 190,000,000 Kw.H. generated; for all New England, 140,000 Kw. and 300,000,000 Kw.H.

This would mean that during the next ten years approximately 1,400,000 Kw. of central station capacity must be added to that already existing in New England, in addition to replacements.

To electrify the additional railroad trackage, on which electrification would be desirable in the near future, would require about another 1,000,000 Kw. of station capacity and 2,000,000,000 Kw.H. per year after the electrification is accomplished. Such electrification of the railroads will depend upon their financial condition.

The question before us, and which we are now considering, is where can the necessary increase in power be obtained at reasonable costs.

There is undeveloped water power in New England at sites where 1,000 H.P. or more is available for 60 per cent of the time, about 860,000 H.P. or 640,000 Kw. If it could all be fully developed for 50 per cent load factor this would require a station capacity of 1,720,000 H.P. or 1,280,000 Kw., and would produce about 4,830,000,000 Kw.H.

This would be sufficient to take care of the requirements for several years not considering the electrification of railroads, but unfortunately about three-quarters of this undeveloped power is in Maine, and under the existing laws cannot be exported. There remains in the rest of New England about 160,000 Kw., equivalent to about 1,200,000,000 Kw.H. Most of this power will not be developed in the near future because of the high cost of the development and of delivered current.

It appears that in all New England, including Maine, enough could be developed at reasonable cost to produce about

3,000,000,000 Kw.H., and of this only a small portion is in the Massachusetts–New Hampshire–Rhode Island district, — the area with which this report is mostly concerned. The balance (requiring interstate transportation) is not available in the absence of legislation or Supreme Court ruling declaring electric power to be a lawful article of commerce.

Some additional water power can be obtained from the small undeveloped powers, and used either locally or as feeders to larger systems. Some additional surplus power can be supplied at Lawrence, Holyoke, and Turners Falls. A greater amount of power can be obtained from some existing properties by redeveloping and getting greater efficiency and capacity.

The total from all such sources is relatively small compared with the total power requirements for New England's growth, although important to individual plants.

In view of the above, it appears that the great bulk of the power for New England's additional requirements, particularly in the district centering about eastern Massachusetts, must come from the following:

(*a*) Large public service steam plants, located not far from the load centers and so as to obtain coal at the lowest rates, and containing large units and interconnected so as to run on high load factors at minimum operating cost; or

(*b*) A supplementing of such steam plants in New England by large water powers in Canada, if proper agreements can be made for the export of electric current.

There are two potential sources of such water power, — the large developments on the tributaries of the St. Lawrence in Quebec, in the early construction of which private capital is already engaged, and which can be economically developed in progressive steps, and the still larger developments on the St. Lawrence, which undoubtedly must wait for the international canalization of the river.

Broadly considered, the development of water powers as fast as the load is created to absorb their output is highly desirable as a measure of conservation of irreplaceable fuel resources. Nevertheless, they must be justified economically before they can attract the necessary capital.

Taking a broad view of the demands that will be made in the near future upon every available resource for transportation and power, it is merely a question of time before the St. Lawrence Canal will be constructed. It is possible that permanent power from this source may be available for New England by 1935 or 1940.

In the meantime, it is to the mutual advantage of both New England and Quebec to promote for their joint use the early development of some of the water powers on the tributaries of the St. Lawrence. The crowded industrial centers in southern New England need this water power which now runs to waste, and the domestic plants and paper industries of Quebec look to this side of the border for their essential coal, the cost and difficulty of securing which is continually increasing.

The inference should not be drawn from comparisons of cost that have been made in the report that it is possible for water power to free the industries from their dependence upon a supply of coal; it can merely prevent the cost of power from mounting to continually higher levels, and it can lessen the hazard due to interruptions of the coal supply. If such water power were to be imported in competition with (instead of supplementary to) any and all steam power, its load factor would be reduced and its cost increased above that shown in the estimates.

The hourly load requirements of industries are so variable that even when tied together in large power systems the annual peak load is two and one-half times the average load. Water power from a distant source will best serve New England by being transmitted at as uniform a rate as possible, that is, on a high load factor, and delivering as much surplus power as can be absorbed by the shutting down of steam-driven units while water is wasting over the dams. Hence, such imported water power will be used to supplement the steam power, and one of the principal uses of the near-by steam plants will be to take the load peaks in regular and stand-by service. Very few steam-driven units will be run at night with these large supplementary water powers available. The steam load factor, or hours of operation, is bound to be less and the water load factor more than for the average power demand.

Both the size and character of New England's load requirements will continue to demand fuel to burn for a large part of the load. It is to be expected that the interconnection of large water power and steam plants will result in dismantling only the smaller and less efficient steam plants.

Finally, central-station power, distributed by large interconnected systems, is the logical source of supply for over three-quarters of our growing industrial load. The cost of this power can be kept from steadily increasing only by the early importation of water power capable of relieving fuel-burning stations of a large share of the base load.

MEMOIRS OF DECEASED MEMBERS

RUDOLPH HERING*

RUDOLPH HERING, son of Dr. Constantine and Theresa (Buchheim) Hering, was born in Philadelphia, Pennsylvania, February 26, 1847, and there attended school until 1860. Then he was sent to Dresden, where he attended the public high school and the Royal Saxon Polytechnic Institute, being graduated as Civil Engineer in 1867. He married, first, Fannie Field Gregory, of which marriage two children, Oswald and Ardo, survive, and second, Herminie Buchheim, who with her three children, Dorothea, Paul and Margaret, survive him. His ancestors specialized in the professions of medicine and music. He became a member of the Boston Society of Civil Engineers June 17, 1896, and continued until his death May 30, 1923.

For nearly five years after returning from Saxony, he was engaged as an assistant engineer on the development of Prospect Park, Brooklyn, and then Fairmount Park, Philadelphia. In 1872 he was astronomical observer of a government expedition which explored Yellowstone Park. His next three years were occupied with the design and supervision of construction of Girard Avenue Bridge, Philadelphia, after which he became Assistant City Engineer in charge of sewerage.

About this time the National Board of Health was empowered to investigate the epidemics of yellow fever then frequent in cities of this country. Suspecting some connection between these epidemics and the inferior municipal sewerage system, the Board sent Mr. Hering to make a thorough study of European practice. As the fruit of his labors a report was published in 1881, which has been characterized as the most important report ever appearing in the United States on the fundamental principles and the arrangements of structures for the satisfactory removal of household wastes by water carriage.

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* Memoir prepared by Alfred D. Flinn and Robert Spurr Weston.

Upon completion of this engagement, Mr. Hering began his consulting practice, interspersed with several outstanding commissions, which, as years passed, earned for him by general consent the designation of the Dean of Sanitary Engineering in America. Between 1882 and 1885 he had field supervision, under General Ludlow, of an exhaustive study of new water-supply sources for Philadelphia. From 1885 to 1887 he was chief engineer of the Chicago Drainage and Water Supply Commission, created to recommend a plan for keeping the city's sewage out of Lake Michigan, then and now the source of water supply. This Commission's studies led toward the Chicago drainage canal scheme. About 1888, after extensive investigation, he reported to General Newton upon the collecting and outfall sewers of New York, recommending extension of the latter from bulkhead to pierhead lines. At this time Mr. Hering established his office in New York, which was his headquarters for more than thirty years. For several years following 1895 he was one of the consulting engineers to the Metropolitan Water Board, developing new sources and enlarging old systems for Boston and environs. December, 1902, to November, 1903, he was a member of the Burr-Hering-Freeman Commission, reporting projects for new water supplies for Greater New York.

About 1890 Mr. Hering turned his attention to the germ theory of disease, then gaining recognition from the medical profession. He grasped its significance for sanitary engineering, particularly water supply and sewage disposal. He kept thoroughly informed of progress in Europe and America. He was one of the first to recommend "mechanical" water filters, as he did for Atlanta. Notwithstanding his important services for the water supplies of New York, Philadelphia, Washington, New Orleans, Columbus, Montreal, Minneapolis, and many smaller municipalities, it was to sewerage and to sewage and waste disposal that he devoted the major portion of his energies for many years. President Harrison appointed him chairman of a commission to prepare a program for improvement of Washington's sewerage system, Frederic P. Stearns and Samuel M. Gray being the other members.

Mr. Hering had George W. Fuller for partner in practice from 1901 to 1911, and John H. Gregory from 1911 to 1915.

Throughout an active career, Mr. Hering was ever responsive to younger engineers seeking advice, inspiration, or other help. His familiarity with European developments in engineering enabled him to make available to engineers in this country the latest knowledge gained in the countries then leading in progress. He was a generous worker on committees of many technical organizations and in civic activities. For the American Public Health Association particularly he rendered important services on collection and disposal of refuse. Late in life, in joint authorship with Samuel A. Greeley, he wrote a book on "Collection and Disposal of Refuse." He was the sole or an associate author of a few other books, besides many professional papers and articles and public reports.

He was a member and held offices in many technical societies in America and Europe. He was an honorary member of the New England and the American Water Works Associations. In 1907 the University of Pennsylvania conferred the honorary degree of Doctor of Science, and in 1922 the Polytechnic Institute at Dresden bestowed an honorary Doctor of Engineering.

Mr. Allen Hazen, from years of intimate contacts with Mr. Hering, has contributed in a letter some paragraphs of personal interest, which are quoted here.

> The first time I ever met Rudolph Hering was when he visited the Lawrence Experiment Station. He had his son with him, then a school boy. Mr. Hering was much interested in the work and seemed to understand it better than most visitors. He was kindly in disposition and we had a good time together. It was not long after that, that I returned the visit in New York. He was living at the Grand Union Hotel. The main purpose of the visit was to talk over the general aspects of our Lawrence work. This we did and in a way that was most helpful to me. This was more than thirty years ago.
>
> Later on I saw Mr. Hering a great deal and had frequent professional engagements where we worked together. One of the earliest was at Altoona, Pennsylvania, and out of this grew the construction of the first Altoona Sewage Disposal plant, — a plant, by the way, that is still in successful operation with only minor changes. This is an unusual record for a twenty-five-year-old sewage-disposal plant in America.

I remember on one of his early visits his telling me about the theory of music. It was something I knew nothing whatever about, but I was impressed by the fact that Mr. Hering was not only fond of music, and was a regular attendant at the Seidl Sunday afternoon concerts at the Lenox Lyceum, but that he understood the theory of wave lengths, and the interference of different kinds of waves, and the effects that were produced by the interference.

Mr. Hering had a thoroughly logical mind, and its action had his entire confidence. When he arrived at a conclusion he acted upon it, and there was no uncertainty in his mind as to the processes by which the results had been reached. These mental processes were a little different from those of most Yankees, and it was not always easy for a Yankee to follow him through the steps of his procedure. However, I firmly believe, as a result of many experiences, that those processes were sound. I frequently checked them in my own ways, which were quite different (I mean the procedure was different), and the general agreements of the results gave me confidence in his mental processes, even when I could not entirely follow them.

In a business way Mr. Hering had the peculiarity of some other men with brilliant minds that we have known. It is hardly an exaggeration to say that he was wholly lacking in what we should call business sense. Sometimes he charged so little for his professional services that clients were surprised and wondered why a man of his standing should charge so little, and, on the other hand, perhaps less frequently, he would charge too much and so create dissatisfaction. This was not from selfishness or desire for gain, but simply from lack of a sense of business proportion.

The man was absolutely outspoken, and this was sometimes a source of embarrassment. He was German by lineage and German by training, and his sympathies with Germany were very warm. When the great war broke out, as was natural, he leaned to the Germans and the German point of view more than most of us. I have no doubt the same might have been said of many other Americans of German descent, but in his case the matter was made more difficult by the frankness with which he spoke of many things and his desire to have us agree with his point of view. Intercourse became difficult, and I only really saw him to have any talk with him a very few times after the outbreak of the war. It was in the early stages of the war, before we were in it, that he made a visit to an old friend in Canada. The friend told me about it afterward. The man was very fond of Mr. Hering, and was willing to do anything for him, but he told me that it had been the most uncomfortable week in his life. Mr. Hering would not stay quiet, but insisted upon going about and meeting people, and everywhere he went he talked about the war in a way that seemed innocent enough to him, but which left the friend in a constant state of alarm as to its effect upon those who did not know him. He said he never heard the doorbell ring without expecting to see the police come in to get his German friend. However, in spite of this, I believe Mr. Hering was thoroughly American. It was only that he so fully understood the German point of view and sympathized with it and talked about it in a way that it was hard for others to understand who had other points of view and other sympathies.

Mr. Hering was an optimist. He enjoyed good health, good digestion and a full life, and always took a healthy view of things even when matters turned against him. He certainly did a great deal for the development of water supply and sewage disposal in this country.

You may be interested in my telling you about the last time I ever spoke to Mr. Hering. Mr. Leavitt and I had arranged to entertain the members of the Institute of Consulting Engineers at Mr. Leavitt's home, and I was to take care of some of the men at Dobbs Ferry. The secretary sent out the notices. There was a telephone call from Mr. Hering, when he spoke of the notice and of his desire to be one of the guests at my house, and we made the arrangement quite definitely for that. He spoke in his usual firm voice as if quite well, but when I went to the train he was not on it. Some one at the meeting had heard the news of his death.

One of the writers of this memoir first met Dr. Hering on a stream pollution case in Worcester. This was nearly twenty-eight years ago. Subsequently he became associated with him on several works and cases and on committee work for technical societies. From the first of these contacts, Dr. Hering's interest in scientific things for their own sake and his vision of the possible development of the sanitary arts were an inspiration and a hope, especially to a young man in a field so new. During the many years that the writer enjoyed Dr. Hering's friendship, he has always been conscious of his kindly interest, his love of truth and his utter lack of commercialism. Confident as he was of his own abilities and in the conclusions of his own mind, he was free from arrogance and receptive to light from any source. To such a life sanitary engineers owe much — to no one more.

In the year preceding his death, Mr. Hering made an extended foreign tour, visiting many places in Europe connected with his student years and earlier professional engagements. He planned it as a farewell journey. One of the writers of this memoir met him at the Century Club in New York (of which he was a member) a few times shortly before and after this journey. He was the same interesting conversationalist, the same genial companion as in years before, but his face was evidently toward the sunset.

EDWARD ALDEN FREEMAN*

THE death of EDWARD ALDEN FREEMAN, at the early age of twenty-four, occurred on December 13, 1920.

Mr. Freeman was born in Concord, New Hampshire, on August 10, 1896. After attending the public schools of that city and of Providence, Rhode Island, he entered Harvard College in 1914, receiving a John Harvard Honorary Scholarship during his first year, and completing in three years the course required for the arts degree, which he took *cum laude*. In September, 1917, he entered the Massachusetts Institute of Technology and completed in October, 1918, the work required for the degree of Bachelor of Science in Civil Engineering, being awarded that degree both by Technology and Harvard as of the class of 1919.

Although he was a member of the Harvard Regiment, his eyesight was such that he was unable to pass the physical examination for entrance to Plattsburg with the Regiment, and because of this defective eyesight he was also prevented from entering active military service in the United States Army. Fortunately, however, his engineering training made it possible for him to enter the service of his country in a most useful capacity in connection with the construction of the Boston Army Supply Base, where he was employed as a member of the engineering field staff.

During his work at the Army Base he contracted a serious case of influenza and pneumonia which necessitated his giving up all work for several months. In September, 1919, he was sufficiently recovered, however, to engage again in active work and was appointed an assistant instructor in the Department of Civil and Sanitary Engineering at the Massachusetts Institute of Technology. Following a year of extremely satisfactory service in that capacity, he entered the employ of Fay, Spofford & Thorndike, Consulting Engineers, and was sent to Springfield as an inspector and instrumentman in connection with the construction of the Hampden County Memorial Bridge across the

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* Memoir prepared by Professor Charles M. Spofford.

Connecticut River at that city. While engaged upon this work he had a sudden attack of appendicitis, which resulted in his untimely death.

In addition to being a member of the Boston Society of Civil Engineers, he also belonged to the Harvard Club in Boston, the Alpha Sigma Phi Fraternity at Harvard, and the First Congregational Church at Newton, Massachusetts.

Mr. Freeman, during his term of service on the instructing staff at Technology, was under the immediate observation of the writer, who found him not only an exceptionally competent assistant because of his ability, his sense of responsibility, his faithfulness, and his anxiety to do everything possible for the institution and for his superiors, but also a young man of engaging personality with whom it was a pleasure to be associated. In his death the profession of civil engineering lost one who bade fair to attain notable success.

FRANK J. NOWELL*

Frank J. Nowell was born in Kennebunkport, Maine, in 1853, the son of George W. Nowell, a Maine sea captain, and Frances (Jefferds) Nowell.

His ancestors came to Virginia with the French Huguenots early in the seventeenth century, and a branch of the family moved to Maine in 1720.

Mr. Nowell was educated in the Farmington, Maine, Academy. Here he was a classmate of former Mayor Edwin U. Curtis of Boston.

After finishing school he worked in the engineering departments of several Maine railroads, coming to Boston in 1890. From 1890 to 1897 he was employed by the Metropolitan Sewer Board of Massachusetts and the Boston & Maine Railroad, entering the employ of the Metropolitan Park Commission in the latter year, and working there continuously until the time of his death.

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* Memoir prepared by David A. Ambrose, George W. Dakin, and John E. L. Monaghan.

He was a designing draftsman of eminent ability, and his work on the design of parkways, landscape developments, bridges, etc., was of a high order. He was considered one of the best topographical draftsmen in this vicinity, and was an accomplished photographer, having done a great deal of very efficient work of this character for the Metropolitan Park Commission.

Mr. Nowell was a Blue Lodge Mason, a member of the Royal and Select Masters of Massachusetts, the Royal Arch Chapter, the Council, and the Knights Templars.

He was a member of the Boston Society of Civil Engineers, past President, Vice President, and Treasurer of the Civil Engineers Association of Boston and Vicinity under Civil Service.

During the last ten years of his life he devoted much time and energy and was very successful in assisting in the reform of civil service regulations as applied to public service engineers, and in obtaining adequate compensation for men in public engineering service. He was well known and respected by members of the Massachusetts General Court, before committees of which he often argued for improved conditions of employees in the public service.

A typical Yankee, with an abundant supply of intelligence and wit, he was a most interesting and entertaining after-dinner speaker. Home-loving, charitable, honest, courageous, he did much for the material advancement of his fellows, and was honored and beloved by all who knew him.

Mr. Nowell is survived by his wife, Mrs. Josephine B. (Torgersen) Nowell, and one daughter.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

DESIGNERS SECTION

BOSTON, April 9, 1924. — The regular April meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.10 P.M. by Chairman Edward H. Cameron.

The report of the annual meeting was read and approved.

The Chairman introduced Harry L. Bowman, Assistant Professor of Structural Engineering at the Massachusetts Institute of Technology, who gave a "Talk on Secondary Stresses." Professor Bowman distributed among those present at the meeting diagrams and formulas of secondary stresses in a typical bridge truss, and proceeded to explain them in detail.

The talk was followed by a discussion of unusual interest, in which Professor Spofford, of M. I. T., and Mr. Guppy, Engineer of Structures, B. & M. R.R., took a prominent part.

There were 70 members and visitors present.

The meeting was adjourned at 7.35 P.M.

WALDO F. PIKE, *Clerk.*

NORTHEASTERN UNIVERSITY SECTION

BOSTON, April 30, 1924. — The annual meeting of the Northeastern University Section of the Boston Society of Civil Engineers was called to order at 5.45 P.M. in the Society Rooms at 715 Tremont Temple, Boston. Chairman Harold F. Kelly presided.

Nominations for officers for the ensuing year were made from the floor.

The following were elected:

Chairman — Sidney S. Anthony.
Vice-Chairman — George H. Meserve.
Clerk — Wilbert H. Connor.
Executive Committee — Roger W. Squier, Theodore T. Lessard, Harold A. Buck.

The Chairman then delivered a brief address in review of the past year and thanked the members for their co-operation.

This was followed by an address on the possibilities of the Society, given by Professor H. B. Alvord.

The meeting adjourned at 6.45 P.M.

Respectfully submitted,
FRED W. CHASE, Jr., *Clerk*.

HIGHWAY SECTION

BOSTON, May 1, 1924. — A meeting of the Highway Section was called to order at 7.15 P.M. Mr. A. W. Dean, temporary chairman, appointed Mr. A. B. Appleton temporary clerk.

The report of the Nominating Committee was read and approved.

Voted, That the Clerk cast one ballot for the following officers for the balance of the year:

Chairman — Arthur W. Dean.
Vice-Chairman — Benjamin F. Bates.
Clerk — Arthur B. Appleton.
Members of Executive Committee — David A. Ambrose, Joseph A. Tomasello, Henry A. Varney.

The By-Laws as recommended by the Committee were adopted.

After the election of officers and the adoption of the By-Laws there was a general discussion as to the subject for the next regular meeting, on May 28.

It was voted to hold the next meeting at 7.45 P.M.

Adjourned at 7.55 P.M.

A. B. APPLETON, *Clerk*.

APPLICATIONS FOR MEMBERSHIP

[May 15, 1924]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

Bowman, Harry L., Watertown, Mass. (Age 35, b. Philadelphia, Pa.) B.S., Penn State, 1911; S.M., Massachusetts Institute of Technology, 1914. Experience: June, 1911–September, 1913, June, 1914–January, 1915, June, 1915–September, 1915, with the American Bridge Company, Pencoyd, Pa.; January, 1915–June, 1915, instructor in Purdue University; September, 1915–April, 1918, principal assistant to C. E. Smith, Construction Engineer, St. Louis, Mo.; April, 1918–September, 1919, assistant engineer, Bridge and Building Department, Philadelphia & Reading Ry.; September, 1919–September, 1920, instructor in civil engineering, M. I. T.; September, 1920, to date, assistant professor of structural engineering, M. I. T. Refers to J. B. Babcock, E. H. Cameron, C. M. Spofford, Hale Sutherland.

Hadley, Norris Edmund, West Somerville, Mass. (Age 46, b. Boston, Mass.) Graduate of Tufts College. With Massachusetts Harbor and Land Commission on surveys from May to December, 1906; with American Bridge Company as structural and bridge draftsman at Ambridge, Pa., plant, to February, 1909; in similar position with Boston Bridge Works until July, 1918; designer and structural draftsman in office of Bridge Engineer, B. &

M. R.R., July, 1918, to September, 1919; since September, 1919, with Boston Bridge Works as assistant engineer and structural estimator and draftsman. Refers to M. F. Brown, H. M. Chadwick, Pusey Jones, E. D. Mortenson, J. C. Moses, K. C. Reynolds.

HAZELWOOD, SUMNER, Point of Pines, Revere, Mass. (Age 45, b. Bangor, Maine.) Educated at Massachusetts Institute of Technology. Experience: 1902–06, draftsman with Arthur T. Gray, Boston; 1906–07, with firm in New York; 1907–10, checker; 1910–12, designer; 1913–17, in business for self; 1917–19, in the army; 1919–20, designer, New England Structural Company; 1920–21, engineer, with French & Hubbard; 1921–24, in business for self, with Parker, Thomas & Rice, and at present with Aberthaw Company. Refers to R. E. Bates, C. B. Breed, B. W. Guppy, A. G. Martin, J. F. Wilber.

KITFIELD, PHILIP HOOPER, Swampscott, Mass. (Age 25, b. Swampscott, Mass.) Graduate of Dartmouth College, 1920; also of Thayer School of Civil Engineering in 1921. May, 1920, to October, 1920, was assistant resident engineer and timekeeper on mill construction; from May, 1921, to date, with Massachusetts Department of Public Works, Division of Highways, as assistant to F. C. Pillsbury, project engineer. Refers to A. B. Appleton, R. W. Coburn, A. W. Dean, E. H. Kitfield, W. N. Wade.

PROCTOR, CLARENCE DIVOLL, Somerville, Mass. (Age 39, b. Charlestown, N. H.) Graduate of Harvard University with degree A.B.; completed course of Structures at Franklin Union. Was structural steel detailer and estimator for A. T. Eastman & Co. to 1912; reinforced concrete detailer and designer with E. A. Tucker Co. to 1914; estimator and chief engineer with Concrete Steel Products Company to 1919; engineer in Boston office of Concrete Steel Company to 1923; in charge of reinforcing bar department of Penn Metal Company to 1924; at present with Concrete Steel Company. Refers to F. S. Brennan, B. S. Brown, E. H. Cameron, J. P. Gallagher, T. R. Lyons.

LIST OF MEMBERS

Additions

Conant, Elbridge R. — 168 Winthrop Rd., Brookline, Mass.
Cummings, Matthew J. — 239 Talbot Ave., Dorchester, Mass.
Morris, Frank H. — 95 Hudson St., Somerville, Mass.

Changes of Address

Archibald, Whittemore C. — 42 Lawrence St., Waltham, Mass.
Atwood, Joshua — 501 City Hall Annex, Boston, Mass.
Barton, Kenneth L. — 27 Brook St., Brookline, Mass.
Bates, Rufus E. — 114 Adams St., Braintree, Mass.
Bigelow, W. W. — 333 Washington St., Boston, Mass.
Brackett, Leroy G. — 16 Monument St., W. Medford, Mass.
Coburn, William H. — 68 Devonshire St., Boston, Mass.
Cross, Ralph U. — 6 Wheeler Ave., Worcester, Mass.
Cummings, W. Warren — 126 High St., Boston, Mass.
Curtis, Greeley S. — 26 Evans Way, Boston, Mass.
Deming, Guy S. c/o Merritt-Chapman & Scott Corp., New London, Conn.
Drew, Samuel T. c/o Metcalf & Eddy, 14 Beacon St., Boston, Mass.
Fernald, Clarence T. — 31 St. James Ave., Boston, Mass.
Flynn, Francis T. — 130 Hamilton St., Dorchester, Mass.
Hart, Linton — V.-P., Chas. R. Gow Co., 957 Park Square Bldg., Boston, Mass.
Harwood T. T. Hunter — 2 Jewett St., Rockport, Mass.
Holway, William R. — 508 Wright Bldg., Tulsa, Okla.
Hosmer, Charles I. — 40 Prospect St., Turners Falls, Mass.
Kent, Robert W. — V.-P., Bigelow, Kent, Willard & Co., Park Square Bldg., Boston, Mass.
Klein, Zoltan — 531 West 179th St., New York, N. Y.
Knowles, Morris — 507 Westinghouse Bldg., Pittsburg, Pa.
Lawrence, William H. — 122 Newbury St., Boston, Mass.
Leland, Franklin E. — Auburndale, Mass.
Macaulay, Ralph F. — 36 Orchard St., Cambridge, Mass.
Nichols, Hall c/o Aberthaw Company, 27 School St., Boston, Mass.
Ober, Arthur J. — 16 Gibbs Ave., Newport, R. I.
Plimpton, Arthur L. — 31 St. James Ave., Boston, Mass.
Pond, Robert W. — 11 Beacon St., Boston, Mass.
Rice, James — P. O. Box 10, Forest Hills, N. Y.
Richards, Walter C. — c/o Turner Construction Co. Box 644, Woonsocket, R. I.
Robinson, Byron A. — Union Station, Burlington, Vt.
Rogers, Edwin H; — Chief Engr. Metropolitan Planning Board, 11 Beacon St., Boston, Mass.

Sawtelle, Harry F. . . . . . North Scituate, Mass.
Stackpole, Miner R. . . . . . . 20 Pike St., Augusta, Me.
Stafford, Roland G. . c/o N. J. D. W. S. Commission, Wanaque, N. J.
Stearns, George H. . . . . R. F. D. No. 1, Medway, Mass.
Sulesky, Adam E. . . . . . . 31 Elizabeth St., Lynn, Mass.
Taylor, George . . . . 675 Concord Ave., Cambridge, Mass.
Thompson, Harry L. . . . . Sanitary District of Chicago,
910 So. Michigan Ave., Chicago, Ill.
Toole, Cameron S. . . . . 99 Pearl St., Clinton, Mass.
Tucker, Lester W. . . . . 5 Erie Ave., Rutherford, N. J.
Watson, George N. . . . 154 Summer St., Watertown, Mass.
Wertheim, Leslie J. . . . Park Square Bldg., Boston, Mass.
Williams, Frederick C. . . . c/o H. L. Cooper & Co., Inc.,
Wilson Dam, East Florence, Ala.
Williams, William F. . . . . 412 State House, Boston, Mass.
Wilson, Herbert A. . Police Comm'r, 29 Pemberton Sq., Boston, Mass.
Winslow, Earl H. c/o Metcalf & Eddy, 14 Beacon St., Boston, Mass.
Worcester, Robert J. H. . Lockwood, Greene & Co., Piedmont Bldg.,
Charlotte, N. C.
Wyner, Henry I. . . . 22 T St. (P. O. Box 467), Allerton, Mass.

LIBRARY NOTES

Book Review

"Steel and Timber Structures" by George A. Hool and W. S. Kinne, Professors of Structural Engineering, University of Wisconsin. First Edition. McGraw-Hill Book Company, Inc., New York. 695 pp.

Reviewed by Lewis E. Moore*

"Steel and Timber Structures" is the fifth of the series of six volumes designed to cover all the principal kinds of modern civil engineering structures. The book is written by fifteen specialists, each of whom handles a particular subject.

The text is divided into sections and covers steel office buildings, steel mill buildings, roof trusses, short span steel bridges, timber bridges and trestles, steel tanks, chimneys, structural steel detailing, fabrication of structural steel, steel erection, estimating steelwork, and materials; and has three appendices, consisting of the American Railway Engineering Association Specifications for steel railway bridges and the American Society for Testing Materials specifications for structural steel for buildings and for bridges.

As is to be expected with so many authors, the method of treatment of the different subjects differs to some extent. For instance, in the chapter on Steel Buildings, an excellent general view of the whole subject from foundation to steeple is given, going into details only far enough to indicate their general type, and including the essentials which must be observed to obtain an economical structure; while the chapter on Roof Trusses goes into the detailed design of certain trusses, figuring them out to the last rivet.

The portion on Steel Mill Buildings is largely descriptive of details of buildings which have already been built, instead of confining itself to the principles underlying construction.

Timber Framed Floors and Roofs are treated in about eighteen pages. This chapter is followed by a very good chapter on Slow Burning Timber Mill Construction, which not only gives the general principles on which such a design should be based, but also tells what mistakes to avoid.

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* Consulting Engineer, 73 Tremont Street, Boston, Mass.

The chapter on Roof Trusses goes very much into details of design. Ornamental roof trusses, including braced arches, hammer beam trusses, scissors trusses and other types used mostly in ecclesiastic architecture are included.

The chapter on Short Span Steel Bridges plows up again a well-tilled field. There is nothing in the treatment which is new or which differs from that ordinarily found.

Timber Bridges have been approached from the standpoint of giving the timber bridge its proper economical place, and this has been well done. The writer of this portion has succeeded admirably in pointing out the essentials for long life and cheap maintenance of timber structures.

The Steel Tank chapter gives illustrations from general practice and the few principles of construction that are involved.

The chapter on Chimneys is confined to steel stacks, and is intended to cover everything from the cross-sectional area required to obtain the proper draft to the details of the riveting.

The three sections on Structural Steel Detailing, Fabrication, and Erection are largely descriptive.

The chapter on Estimating gives methods of procedure and a few costs, but is intended principally as a guide to methods of estimating.

The section on Materials is too brief to cover the subject adequately.

Considering the book as a whole, there is a great deal of useful information in it, but the different chapters are of variable value, owing probably to the differing personal equations of the authors. It is unfortunate that there is no bibliography. A collection of references at the end of each chapter would be a very useful aid to one who wished to pursue the subject more in detail.

RECENT ADDITIONS TO THE LIBRARY

U. S. Government Reports

Fourteenth Census of U. S., Vol. IV. 1920.

Municipal Reports

Boston, Mass. Annual Report of Boston Finance Commission. 1923.

Boston, Mass. Annual Report of City Planning Board. 1922.

Boston, Mass. Annual Report of Public Works Department. 1922.

Brookline, Mass. Annual Report of Water Board. 1923.

Haverhill, Mass. Annual Report of Board of Water Commissioners. 1923.

Springfield, Mass. Annual Report of Water Commissioners. 1923.

Wellesley, Mass. Annual Report of Water and Municipal Light Commissioners. 1923.

Miscellaneous

Alternating Current Phenomena. Steinmetz.

American Fuels. Bacon & Hamor. 2 vols.

American Telegraph Practice. Donald McNicol.

American Telephone Practice. Miller.

Chronology of Iron and Steel. Goodale.

Construction of Roads and Pavements. Agg. Gift of McGraw-Hill.

Cram's Modern Atlas of the World.

Electric Traction for Railway Trains. Jansky.

Electrical Meters. Jansky.

Estimating Building Costs and Appraising Buildings. Barnes.

Hydraulics and its Applications. Gibson.

Light, Photometry and Illumination. Burrows.

Oil Engines. Morrison.

Pole and Tower Lines. Coombs.

Power Situation during the War. Chas. Keller. Gift of H. S. Knowlton.

Practical Designing of Retaining Walls. Cain.

Principles of Iron Founding. Moldenke.

Principles of Wireless Telegraphy. Pierce.

Public Utilities. Hayes.

Storage Battery Engineering. Lyndon.

Theory and Calculation of Electric Circuits. Steinmetz.

LIBRARY COMMITTEE.

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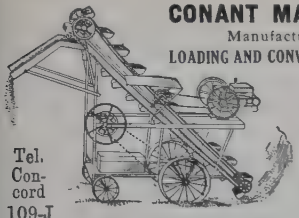

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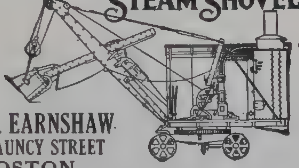

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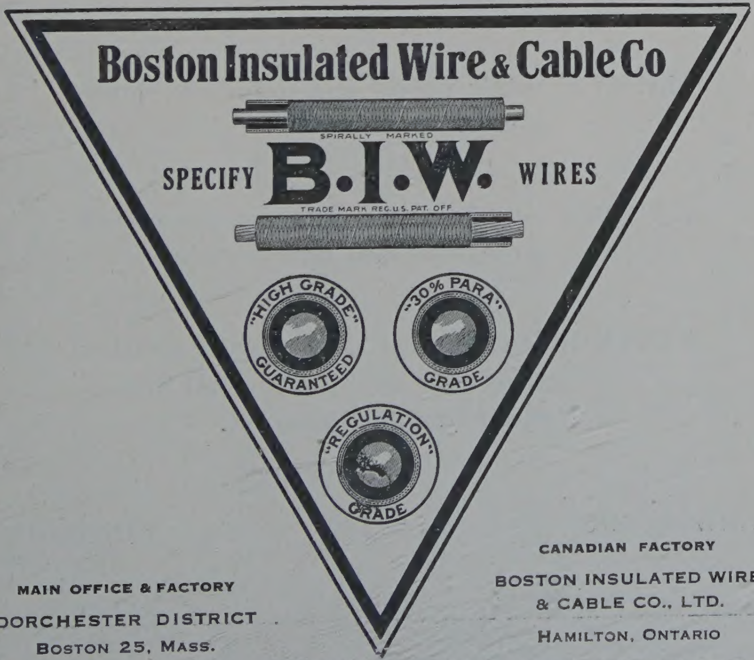

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